JUVENILE DIABETES—GROWTH AND STATURE CHANGES*

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THE problem of the management of the juvenile diabetic is one of the most worthy in the study and treatment of diabetes. On account of the rapid metabolic changes to which the child diabetic is susceptible greater responsibility is encountered than in the treatment of adults. Insulin has served to lessen this responsibility and has made it possible for the child diabetic to grow and develop normally.

LITERATURE LIMITED IN SCOPE

The incidence of juvenile diabetes is relatively small, comprising only about 5 or 6 per cent of the total number of diabetics. The literature contains very little upon this subject except a few reports of single cases. It is the object of this paper to record the changes in stature and weight of a group of sixty-two living diabetic children treated over a period of one to nine years, all of whom are receiving insulin at the present time. Joslin's report [1] of 395 diabetic children treated by him from August, 1898 to September, 1926 is the most extensive recorded. He divided his experience into three eras. The first, the Naunyn era, August, 1898 to January, 1914, comprised 61 cases, of whom 60 are dead. The second, the Allen era, January, 1914 to August, 1922, with 169 cases, of whom 117 are dead. The third, the Banting era, August, 1922 to September, 1926, with 165 cases, of whom only 18 are dead. W. S. Ladd reported thirty-four cases of juvenile diabetes. He emphasized the necessity of sugar freedom to insure the best growth in stature; and also the necessity of controlling body weight and diet. H. J. John [3] reports thirty cases of diabetes in children. Francis S. Smyth [4] reported nineteen cases and called attention to the importance of the removal of foci of infection. Priesel and Wagner [5] reported thirty-nine cases in detail. The diets prescribed by them contain much more fat and less carbohydrate than advocated by any clinic in our country. Many of their diets contain 250 grams of fat and a few as much as 300 grams.

IDEAL STANDARDS IN TREATMENT

Complete freedom from active diabetic signs and symptoms, such as glycosuria, hyperglycemia and acidosis, has been chosen as the ideal standard for a general plan of treatment. The ideal plan also requires that the diabetic child's nutrition approach the theoretical normal standard as closely as possible. Normal nutrition was of course an impossibility in cases of any real severity under former diet treatment alone. These rigid requirements are of course not attained without some difficulty, but by adhering to conservative policies, and keeping in mind the known benefits derived from careful diet application previous to the discovery of insulin, the mild cases of diabetes will be kept mild, and complications will be avoided in the severe.

There are numerous reasons for insisting upon conservative dietary restriction and freedom from glycosuria and hyperglycemia. That diabetes is due to deficiency of the internal secretion of the islands of Langerhans, and that treatment should aim at relieving overstrain of the weakened assimilative function, is generally accepted. Experience has taught us that downward progress may be expected when treatment is relaxed to permit glycosuria for any length of time. Injury from improper diet and breaking of diet is much more quickly demonstrated in juvenile cases than in older persons. Formerly cases of almost hopeless severity could be prevented from further downward progress by relieving glycosuria and hyperglycemia for sufficient period of time to allow regeneration of island function, and tolerance improved with continued relief from pancreatic overstrain.

PATHOLOGY OF DIABETES

Sufficient experimental work on the pathology of diabetes has been conducted to demonstrate progressive destruction of insular tissue during active diabetes. Weichselbaum and Stengel in 1901 showed that degeneration in the form of vacuolative hydropic changes occurred in the islands of Langerhans and that the phenomenon was specific in diabetes. Allen [6] showed that the vacuolative changes varied with the clinical condition. During unchecked severe diabetes vacuolative changes began in four to seven days and reached a maximum in about a month. Within six to eight weeks all beta cells may have disappeared from the pancreas. Copp [7] demonstrated that the hydropic degenerative changes of the island cells are reversible when functional strain is relieved by the administration of insulin, provided hyperglycemia was kept absent. The vacuolated cells recover normal form and granulation within about two weeks after active diabetes is brought under control. Keeping these pathological facts in mind one realizes how important it is to insist upon well-balanced diets to insure complete sugar freedom in both blood and urine at all times.

DIAGNOSIS OF DIABETES MELLITUS

The data included in this paper are based on living children who are known to have true diabetes mellitus for considerable periods of time, and do not include borderline or doubtful cases. The diagnosis of diabetes in children is relatively easy since the classical signs, polydipsia, polyuria and polyphagia and loss of weight are usually strikingly in evidence, in contrast to doubtful diagnostic signs such as weakness, fatigue and vascular degenerative processes as seen in the elderly. The most important diagnostic sign in children is thirst. I cannot recall a single instance of true diabetes in a child who did not have this definite sign; while on the other hand the majority

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of benign glycosurias in children are not associated with changes in water balance. However, any child with glycosuria must be considered diabetic until the contrary is proven.

RELATION OF INSULIN TO DIABETIC COMPLICATIONS

Statistical data of the number of living diabetic children under treatment with insulin as compared with those who died while receiving insulin are of very little importance. The cause of death is usually coma and the reasons are thoroughly evident. The important questions are: "Will the diabetic child of today develop prematurely the common latent complications of diabetes?" and "Can normal growth, height, weight and sexual development be obtained with insulin?" The first question deserves immediate careful consideration, because the future physical welfare of the diabetic child, ten to twenty years hence, may in a great measure be determined today. The common latent complications such as neuritis, retinitis, carbuncles and gangrene occur most commonly in the diabetics who have been careless with diet and have failed to keep blood and urine tests clear. For the most part complications occur in cases of long standing where the initial mildness of the disease permitted a fair glycosuria; the case later becoming severe and finally resulting in the distressing complications mentioned. The inherent nature of diabetes signifies a slowly progressing condition which later in life produces degenerative lesions of the extremities and eyes. Emphasis may be placed upon the fact that diabetic complications rarely occur in cases under thorough dietetic control, and the prevention of complications which are the chief cause of suffering in diabetes is worth the privation of careful diet. Experience with insulin thus far has assured us that the diabetic child can live and will live, and that his expectancy is probably the same as that of his nondiabetic brother. Knowing his predisposing susceptibility to latent diabetic complications, and something of prophylaxis, may we not expect to avoid complications in later years by insisting upon careful measures now?

Diabetic children sooner or later must be treated with insulin. The time of beginning treatment depends principally upon the severity of the case. Some mild ones may forego its use for several months. The quicker insulin is begun the better the final result, because good nutrition is more easily maintained. The musculature of the mildly diabetic child is firm, his complexion clear, and his strength and endurance almost equal to the normal. If he is treated by dietary methods alone for any length of time he soon loses this good muscular tone, the subcutaneous tissues become flabby and pudgy, with retained fluid, and his color becomes pale and sallow. Although insulin restores the body weight and strength in such cases there remains an unmistakable diabetic appearance which has been described as simulating hypothyroid or hypopituitary conditions. By insisting upon the early use of insulin patients may not only be controlled better from the standpoint of smaller insulin dosage, but better nutrition and management is insured.

METHODS OF TREATMENT AND EDUCATION OF PATIENT

Initial treatment should never under any condition be inaugurated with sudden alteration or restriction of diet. The most common mistake is usually sudden restriction of carbohydrate. Fat is the one article of diet which should be restricted first, irrespective of whether acetone bodies are present or not.

Education of the diabetic child or of any diabetic is the surest insurance for success in management. Diabetes is probably the only disease of which the patient should know all about his condition and how to remedy it. Unless the physician educates his patient and teaches him the fundamental principles of diet, insulin dosage and injection, how to make his own urine test, and the dangers of coma and how to prevent it, he may later be considered a responsible party for the patient's death. His responsibility does not end with education. By means of a careful follow-up system he should obtain reports at definite stated intervals to make sure there is no tendency to relax treatment or neglect urine tests. We have used with great satisfaction a "home report" sheet for recording the diet, body weight, daily urine tests and insulin dosage. This report is brought by the patient at each office call or mailed in at specific times.

COMPLICATION OF OBESITY

The greatest complicating factor in diabetic treatment is obesity. The fact that the laity usually consider obesity a sign of general well-being frequently makes it difficult at first for the physician to have his patient keep the weight at or slightly below the normal standard. Body fat is simply a parasite which requires excessive amounts of insulin and adds another risk to an already hazardous condition. The fat child is the one who suffers most from hypoglycemic reactions and has the greatest difficulty in keeping urine tests clear for any consecutive period. An analysis of the coma deaths reveals that 80 per cent were more than 20 per cent overweight. Undernutrition is a serious handicap to the diabetic child, but at the same time overnutrition is more dangerous, and experience has proven that if a choice should be made the former is the more desirable.

The best relief for obesity lies in adequate exercise. The utilization of sugar is facilitated and the tendency to abnormal blood sugars diminished. Obesity is certainly not an etiological factor in juvenile diseases. Only two patients in this series could be considered obese at the onset.

COÖPERATION OF PATIENT NECESSARY

The faithful diabetic child is the easiest of all diabetics to treat, and the unfaithful the most difficult. The former considers his diet part of his religion, and his fidelity exists so long as he is given encouragement. The management of the

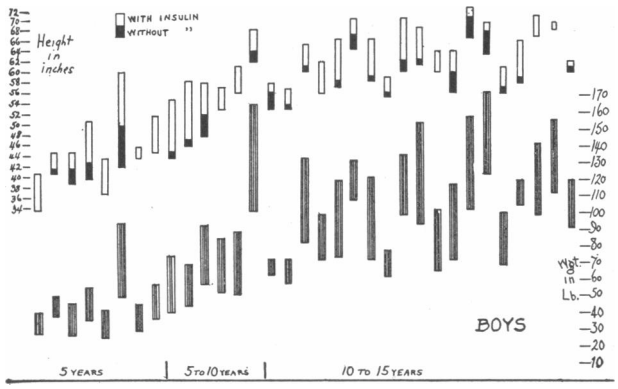

Chart 1

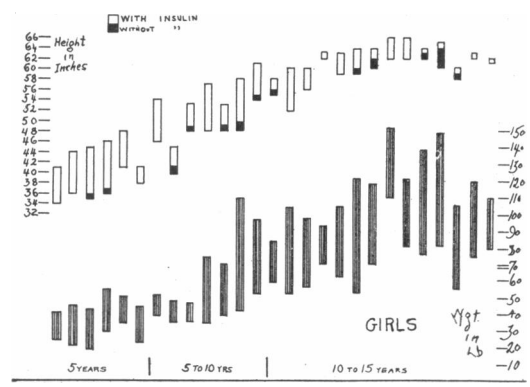

Chart 2

The solid black portions of the vertical columns represent the height at onset of diabetes and on beginning insulin treatment. The upper white portions of the same columns indicate the growth in height under insulin therapy. The corresponding series of ruled vertical columns represent the weight in pounds on beginning insulin and the final weight.

unfaithful child, like the management of the illiterate, is frequently a hopeless task. Children up to the age of twelve coöperate best, while after the age of twelve there is a tendency to become careless and to break away from prescribed measures. There is little question but that diabetic children are precocious, keen and mentally alert. Discipline, exercise, hygiene and education should be precisely that of normal children. One should adopt the practice of encouraging the child to prepare for proper school and college training. He should consider early his future work or profession, keeping in mind that sedentary occupations are distinctly contraindicated.

GENERAL DIETETIC PRINCIPLES

The use of rigid diet formulas for determining the required diet for any diabetic patient, juvenile or otherwise, should be discouraged. It not only restricts individuality, but forces ill-balanced diets upon many diabetics. Imagine one's embarrassment upon attempting to give a logical explanation for assigning the same diet to a chubby fat boy and a tall slender girl because they are of the same age and weight. The diet must be arranged to suit the needs of body requirement; fat and carbohydrate being added or restricted as obesity or undernutrition demand.

THE PROTEINS

In assigning the diet, protein deserves the first consideration. It is the one food substance which has the advantage of giving maximum strength and energy with a minimum of carbohydrate and calories. The average child does well and maintains his strength on about 65 grams. They seem to thrive best on animal protein, but it may be used as individual preference dictates. The protein requirement of children is in indirect ratio to the age. Holt estimated the requirement at about 4 grams per kilo in infancy; 2 to 4 grams in childhood; and 2 grams in adolescence. Bartlett [8] recently made a series of observations in diabetic children from 4 to 14 years of age to determine the minimum amount of protein required to establish a positive nitrogen balance and at the same time permit adequate growth in stature, weight and development. In order to establish the requirement he kept in mind the various protein-sparing factors. It is interesting to note that he could establish maintenance with the surprisingly small amount of .6 to 1.0 grams per kilogram body weight. Since we are all aware that the diabetic child gains easily in weight but

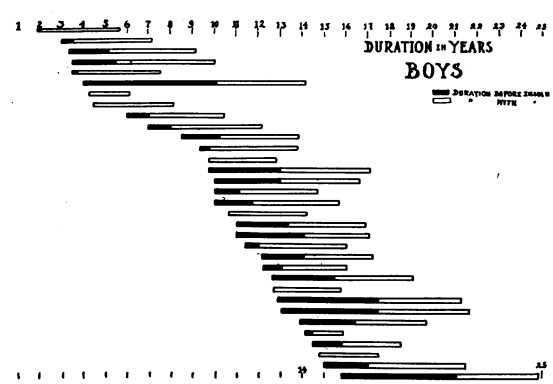

Chart 3

Chart 3—Duration of Diabetes in Years, Boys. The left-hand heavy black columns represent the age at onset of diabetes and the age on beginning insulin treatment. The white portions of the columns represent the duration of life under insulin therapy.

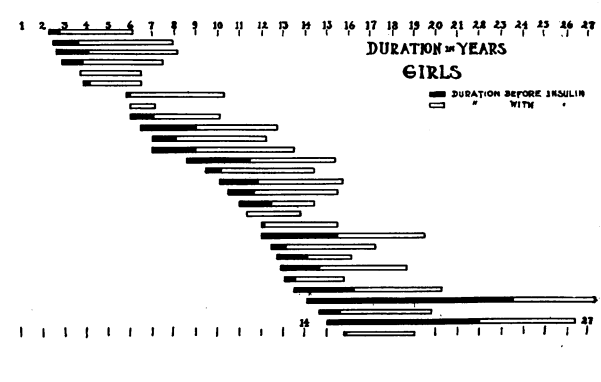

Chart 4

Chart 4—Duration of Diabetes in Years, Girls. The left-hand heavy black columns represent the age at onset of diabetes and the age on beginning insulin treatment. The white portions of the columns represent the duration of life under insulin therapy.

not so much in height, and that protein is one of the chief essentials for the growth of bony structure, one must make sure of adequate protein allowance in the growing child. Horace Gray [9] has made a good compilation of over five hundred diabetic children's diets in various clinics. He called attention to the fact that the expression of diets in terms of calories per kilo and grams per kilo body weight probably gives the most accurate information. He found the average protein assignment to be 2.7 grams per kilo in the first decade. The average protein allotment of the cases here reported is 2.5 to 3 grams per kilo, and may be responsible for the relatively good gains in height. Protein is the ideal food for conserving skeletal musculature; it prevents hunger and helps control obesity.

THE CARBOHYDRATES

Carbohydrate has a stronger glycosuric effect and creates a higher insulin requirement than the caloric equivalent of any other kind of food.[10] There is no constant scale of insulin dosage for the assimilation of any given quantity of carbohydrate. The ratio between grams of glucose and units of insulin varies widely not only in different patients, but also in the same patient under different conditions. Glycosuria and insulin requirement are governed to a very important degree by the total caloric effect of the diet. Joslin has found it safest to keep the ratio of carbohydrate to fat at about 1 to 1; and his "carbohydrate allowance rarely exceeds 100 grams." The giving of promiscuous amounts of carbohydrate to the diabetic encourages carelessness in diet and very soon all discipline is relaxed with generally poor results. Very soon he is willing to risk more fat and total calories and grows obese, the final end-result with which, sad to relate, we are all familiar. Exaggerated amounts of carbohydrate prevent careful stabilization of the blood sugar. The rapid flooding of the organism brings about prompt glycosuria, which is soon followed by hypoglycemia secondary to the high insulin dosage required in the attempt to prevent it. Children require proportional higher carbohydrate than the adult, and carbohydrate should be given so long as glycosuria and hyperglycemia can be avoided. In the early stages it is a very simple matter to give large amounts of carbohydrate, 200 to 250 grams, with small amounts of insulin and still maintain sugar freedom, but when one recalls that diabetes is a progressive disease and tolerance is soon lowered, it is much better to insist upon lesser amounts of carbohydrate in the diet. The general idea that the normal person consumes 400 grams of carbohydrate per day most probably needs revision. The average consumption is probably 250 to 300 grams. In reviewing a series of patients under forced feeding it was found that only the exceptional one could consume more than 350 grams in spite of keen appetite and good digestion. Calculation of one's daily diet will probably lend emphasis on this point, so the generally accepted carbohydrate allowances prescribed by our leading authorities on diabetes hardly work a hardship on our diabetic patients. Eighty to one hundred grams of carbohydrate is a very liberal amount and permits comfortable existence. It is adequate for a small amount of starch and cereal, and is sufficient for a good supply of green vegetables and vitamins. Carbohydrate is the most palatable of all our food substances, and we are responsible to Doctor Banting for the wonderful gift which permits more comfortable existence for the diabetic.

THE FATS

Since diabetes is a disease of total metabolism rather than a disease of carbohydrate metabolism the question of fat in the diet must deserve early consideration on account of its high caloric value. The insulin requirement of the body is very greatly increased by the addition of fat to the diet. Increase in adipose tissue on the body demands a much larger insulin supply than a similar increase in skeletal or bony structure. The increased amount of adipose tissue not only requires extra insulin for the process of food storage and consumption, but the fat cells also consume it at a rapid rate during the process of anabolic and catabolic change. Ladd [2] showed that diabetic children may grow normally on diets which contain only 50 per cent of the total calories considered necessary for the normal child.

COMMENT ON TABLES AND CASE REPORTS

Table 1 is a compilation of data pertaining to age, height and weight changes, diet and insulin requirement of sixty-two living children who have been under treatment with insulin more than one year. Several cases are of remarkable interest on account of severity and longevity, both preceding insulin treatment and subsequently. Case 3 is probably the most severe, as shown by the meager diet necessary for sugar freedom for the thirteen months prior to the discovery of insulin and the high insulin requirement for the increased diet after insulin. Cases 11 and 33 belong in the same category. Case 54 developed diabetes at the age of 14 years and 2 months and adhered carefully to diet treatment for nine and one-half years. She was among the first to receive insulin in 1922. There was partial invalidism during the latter part of her pre-insulin treatment, but insulin has enabled her to almost double the body weight and to complete her collegiate work last year. Case 12 is equally as remarkable on account of the long duration of the pre-insulin treatment (six years) and the youthful age at onset (four years). Case 60 was treated for six years and Case 62, seven years without insulin. Charts 3 and 4 show graphically the age of onset of diabetes, years of treatment without insulin and duration of treatment under insulin.

Changes in Height—Formerly diabetic children grew very little in height if at all. A few mild cases increased a few inches, but all failed to keep pace with the normal child over any prolonged period. Several patients in this series grew three or four inches over periods of two to four years before insulin discovery. Case 12, patient grew

TABLE 1—*Compilation of Data Concerning Sixty-Two Children Under Treatment With Insulin for More Than One Year.*

CASE No.	SEX	AGE: At Onset Yr.	AGE: At Onset Mo.	AGE: At Beginning Insulin Yr.	AGE: At Beginning Insulin Mo.	AGE: Final Yr.	AGE: Final Mo.	DURATION: Before Insulin Yr.	DURATION: Before Insulin Mo.	DURATION: After Insulin Yr.	DURATION: After Insulin Mo.	HEIGHT (Inches): At Onset	HEIGHT (Inches): At Beginning Insulin	HEIGHT (Inches): Final	HEIGHT CHANGE (Inches)	WEIGHT (lb.): At Onset	WEIGHT (lb.): At Diagnosis	WEIGHT (lb.): At Beginning Insulin	WEIGHT (lb.): Final	WEIGHT CHANGE: Before Insulin	WEIGHT CHANGE: After Insulin	DIET: Maximum Before Insulin: Protein	Fat	CH.	Total Calories	DIET: Final, with Insulin: Protein	Fat	CH.	Total Calories	INSULIN (Units)
1	M	1	11	2	0	5	8		1	3	8	34	34	41	0 7	30	29	29	42	0	+13					50	95	45	1235	21
2	F	2	4	2	9	6	1		5	3	4	35	35	43	0 6	27	27	24	42	—3	+18	35	38	5	500	60	70	75	1170	24
3	F	2	6	3	7	7	11	1	1	4	4	34½	34½	44	0 9½	31	31	22	45	—9	+23	10	8	3	120	65	70	100	1290	60
4	F	2	7	4	1	8	2	1	6	4	1	34¾	36	44½	1¼ 8½	30	30	18	43	—12	+25	50	20	5	300	65	62	70	1100	17
5	F	2	10	3	10	7	6	1	0	3	8	36	36	46	1 9	33	33	29	55	—4	+26	40	44	10	600	80	80	85	1400	16
6	M	3	0	3	6	7	2		6	3	8	40	40¾	45	¾ 4¼	40	40	39	51	—1	+12	50	93	40	1200	65	75	80	1250	14
7	M	3	4	5	2	9	2	1	10	4	0	39½	42	44½	2½ 2½	41	30	28	47	—2	+19	35	47	10	600	65	140	91	1880	25
8	M	3	6	5	6	10	0	2	0	4	6	40½	43¾	51	3¼ 7¼	40	40	37	56	—3	+19	50	93	15	1100					45
9	M	3	6	3	8	7	6		2	3	10	37	37	44	—0 7	30	30	26	43	—4	+17					80	84	80	1400	22
10	F	3	8	3	8	6	6		0	3	5	41	41	55½	0 8½	38	38	34	50	—4	+16					80	100	100	1620	24
11	F	3	10	4	2	8	6		4	4	4	37	38½	43¼	1½ 4¾	32	28	23	52	—5	+29	30	18	5	300	70	79	70	1260	66
12	M	4	0	10	1	14	2	6	1	4	1	42½	50	60	7½ 10	33	33	50	96	+17	+46	60	107	50	1400	80	109	150	1600	50
13	M	4	3	4	3	6	1		0	3	10	44	44	46	—0 2	39	30	30	45	0	+15					75	90	90	1570	36
14	M	4	6	4	6	8	2		0	3	8	45	45	52	0 7	42	42	38	58	—4	+20	60	80	60	1200	80	129	80	1900	10
15	F	5	10	6	0	10	4		2	4	4	46	46¾	54	¾ 7¼	40	40	38	51	—2	+13	50	82	15	1000	70	94	90	1500	34
16	M	6	0	7	0	10	5	1	0	3	5	44	45	54¾	1 9¾	43	41	41	76	0	+35	60	60	30	900	85	120	85	1800	97
17	F	6	0	7	1	10	2	1	1	3	1	40	41	44½	1 3½	38	38	35	48	—3	+13	50	33	25	1200	70	71	70	1200	14
18	F	6	0	6	0	7	1		0	1	1	44	44	45	0 1	36	36	36	47	—0	+11					60	85	85	1350	10
19	F	6	6	9	0	12	9	2	6	3	9	48	49	53	1 4	46	46	43	85	—3	+42	50	93	15	1100	60	75	75	1215	12
20	M	7	0	8	0	12	2	1	0	4	2	46	47	56	1 9	45	45	45	70	0	+25	55	102	40	1300	70	128	90	1800	18
21	F	7	0	9	0	13	6	2	0	4	6	48	48½	56¾	0 8¼	47	47	35	75	—12	+40	50	82	15	1000	90	82	100	1500	22
22	F	7	0	8	1	12	2	1	1	4	1	48½	49	53	½ 4	50	40	39	70	—1	+31	55	31	15	800	70	65	70	1150	50
23	M	8	7	10	3	13	8	1	8	3	5	48	52	57½	4 5½	75	75	58	94	—17	+36	60	120	45	1500	90	82	44	2000	22
24	F	8	8	11	5	15	5	2	9	4	0	48	50	57½	2 7½	56	56	42	110	—6	+68	60	100	40	1300	80	90	93	1500	74
25	M	9	4	9	7	13	7		3	4	0	53	53½	57	0 3½	62	52	53	87	+1	+34	70	158	50	1900	100	151	110	2200	26
26	F	9	6	10	2	14	5		8	4	3	55	56	61	1 5	72	52	52	97	0	+45	55	109	25	1300	80	117	80	1700	31
27	M	9	8	9	8	12	10		0	3	2	56	56	60½	0 4½	62	52	52	90	0	+38					75	129	90	1820	20
28	M	9	8	12	0	17	2	3	4	4	2	60	62½	68	2½ 5½	115	115	103	167	—12	+64	60	129	30	1500	80	123	80	1750	54
29	M	10	0	13	0	16	6	3	0	3	6	53	56	58	3 2	80	70	64	73	—6	+9	60	122	40	1500	85	120	110	1860	30
30	M	10	0	11	1	14	7	1	1	3	6	53	54	57¼	1 3¼	70	65	59	73	—6	+14	65	142	40	1700	70	135	75	1800	34
31	M	10	1	11	9	15	8	1	8	3	11	60	61	65½	1 4½	90	90	83	133	—7	+50	55	122	20	1400	80	113	90	1700	90
32	F	10	1	11	10	15	10	1	9	4	0	55	56½	58½	1½ 2	75	66	58	84	—2	+26	60	120	20	1400	70	104	70	1500	30
33	F	10	6	11	7	15	6	1	1	3	11	52	52	60	0 8	72	60	51	105	—9	+54	30	15	5	275	80	197	100	2500	66
34	M	10	7	10	7	14	2		0	3	7	56	56	52	0 6	72	73	73	100	0	+27					80	100	70	1500	72
35	M	11	0	13	3	16	11	3	3	3	8	57	58	65½	1 7½	90	76	73	120	—3	+47	60	120	20	1400	100	144	100	2100	40
36	M	11	0	14	1	17	0	3	1	2	11	64	67	70	3 3	120	117	108	132	—7	+24	70	129	40	1600	100	144	100	2100	36
37	F	11	0	12	5	14	5	1	5	2	0	56	60	60	4 0	58	59	59	98	0	+39	55	115	25	1350	75	106	60	1600	60
38	F	11	4	11	4	13	10		0	2	6	62	62	62½	0 ½	92	72	72	95	0	+23					80	120	100	1800	25
39	F	12	0	12	1	15	6		1	3	5	59	59	63	0 4	72	62	62	114	0	+52	60	120	20	1400	75	100	75	1500	63
40	F	12	0	15	6	19	7	3	6	3	7	59	60	64	1 4	77	73	53	122	—20	+69	40	64	15	800	85	100	100	1640	55
41	M	12	2	14	1	17	2	1	11	3	1	58	59½	66	1½ 6½	83	73	72	123	—1	+51	70	113	50	1500	80	118	80	1700	20
42	M	12	2	13	0	17	0	0	10	4	0	55	56	65	1 9	82	82	63	117	—9	+55	65	100	35	1300	80	140	80	1900	30
43	F	12	6	13	1	17	1	0	7	4	1	53	53	57	0 4	62	62	55	70	—7	+15	50	102	20	1200	70	80	80	1400	25
44	M	11	4	12	0	16	0	0	8	4	0	60	62	70	2 8	105	98	99	135	+1	+36	90		100	2400	100	155	100	2200	34
45	M	12	7	15	6	19	1	2	11	3	7	61	61½	68	½ 6½	120	115	94	155	—21	+61	60	136	35	1600	100	150	100	2000	75
46	F	12	8	14	2	16	2	1	6	2	0	60	62	64	2 2	98	91	72	118	—19	+46	70	102	25	1400	85	151	85	2000	45
47	M	12	8	12	8	15	10		0	3	2	60	60	64	0 4		66	66	103	0	+37					80	150	80	2000	25
48	M	12	10	17	5	21	3	4	7	3	10	56	60	64	4 4	119	90	72	118	—18	+46	50	82	15	1000	90	120	90	1800	34
49	F	12	11	14	8	18	9	1	9	4	1	62	62	66	0 4	124	89	109	152	+20	+43	60	86	20		60	40	50	850	60
50	F	13	1	13	6	15	10		5	2	4	60	60	64	0 4	92	92	81	121	—11	+40	70	120	60	1600	70	80	111	1600	42
51	M	13	1	17	5	22	7	4	4	5	2	56	70	72	4 2	138	111	103	158	—8	+55					100	150	125	2250	40
52	F	13	6	16	3	20	3	2	9	4	0	62	63	64	1 1	104	104	76	138	—28	+62	40	58	5	700	60	70	120	1300	86
53	M	13	10	16	3	19	9	2	5	3	3	63	67½	69	3½ 1½	110	110	125	172	+15	+47	60	120	20	1400	90	164	90	2200	62
54	F	14	2	23	7	28	4	9	5	4	9	60	64	65½	4 1½	90	90	81	148	—9	+67	50	96	10	1100	75	96	85	1504	38
55	M	11	2	14	4	15	8		2	1	4	56	57	61	1 4	75	75	69	100	—6	+31					80	104	60	1500	26
56	M	14	6	15	10	18	6	1	4	2	8	58	59	66	1 7		88	105	120	+17	+15	65	127	25	1500	70	132	35	1400	10
57	F	14	8	15	7	19	10		11	4	3	58	59	60	1 1	72	72	56	105	—18	+49	45	76	10	900	80	80	106	1600	64
58	M	14	9	14	9	17	6		0	2	9	67	67	70¾	0 3¾	100	99	99	142	0	+43					100	135	100	2100	42
59	M	15	0	17	0	21	4	2	0	4	4	70	70	70½	0 ½	120	120	113	157	—7	+44	60	153	20	1700	90	146	80	2000	36
60	M	15	0	21	0	24	10	6	0	3	10	63	64	65¼	1 1¼	120	95	91	120	—4	+29	65	120	15	1400	95	160	100	2200	38
61	F	15	0	15	11	19	0		11	3	1	62	62	62	0 0	80	75	75	120	0	+45					90	120	100	1840	40
62	F	15	0	22	0	26	0	7	0	4	0	62	63	63	1 0	110	110	78	110	—32	+32	50	74	20	950	70	75	70	1210	60

four inches in one and three-fourths years, and Case 48, patient grew four inches in four years and seven months without insulin. Under insulin several remarkable increases in stature have been made; particularly Case 42, patient with an increase of nine inches in four years, and Case 35, patient with eight inches in three years and eight months. The best gain in height was noted in Case 12 patient, namely, ten inches in four years. This mushroom-like growth is in keeping with the experimental work of Osborn and Mendel[11] in which they noted rapid compensatory growth in rats after periods of suppression of growth. Despite failure to grow, average normal size may be regained provided renewed feeding is commenced before the usual period of growth is ended. A glance at Charts 1 and 2 shows the contrast of growth in height after renewed feeding in the younger children as compared with the older ones. The average increase in height of children 1 to 5 years of age was 6.3 inches; 5 to 10 years, 4.3 inches; 10 to 15, 3.0 inches (Table 2). Case 54 showed the least increase

TABLE 2—*Summarizes average duration, height change, weight change before and after insulin administration. The maximum and minimum changes are also tabulated. The age refers to the age at onset of diabetes.*

AGE		DURATION before insulin yr.mo.	DURATION after insulin yr.mo.	CHANGE IN HEIGHT before insulin (inches)	CHANGE IN HEIGHT after insulin (inches)	CHANGE IN WEIGHT before insulin	CHANGE IN WEIGHT after insulin	INSULIN units
1–5	Average	1–0	3–8	¾	6.3	–4	+19	23
	Maximum	6–1	4–6	8	9.0	–12	+46	50
	Minimum	–1	2–4		3.0		+12	10
5–10	Average	1–3	3–8	1	4.3	–4	+35	34
	Maximum	3–4	4–6	4	9.0	–17	+68	50
	Minimum		1–1		3.0		+11	10
10–15	Average	2–1	3–6	1.6	3.0	–7	+40	44
	Maximum	1–2	4–3	4.	8.0	–32	+67	90
	Minimum		1–4		.5		+9	10

in height. She has grown only one inch after almost five years of insulin treatment. This might be expected on account of her age; the period of growth being passed during the nine and one-half years of pre-insulin treatment.

Changes in Body Weight—It is a very easy matter for a diabetic child to increase in body weight, barring existing infections such as chronic sinusitis or antrum infections. The best treatment calls for restriction of the diet to keep the increase within normal standard limits. Joslin prefers an increase of approximately seven pounds a year, which is the average for the normal child. The children in this group increased at about that rate. Nine children in this series have more than doubled their body weight. The severity of several of the cases is shown by the tremendous weight lost under pre-insulin treatment: Case 4, patient lost from 30 pounds to 18 pounds, or 40 per cent of the total body weight, within a period of one and one-half years, and Case 40, patient lost from 73 pounds to 53 pounds, or 36 per cent of the total body weight, during three and one-half years of pre-insulin treatment. The greatest

TABLE 3 — *Shows the percentage of deviation above and below normal standard weight. The age refers to the final age of the patient. Calculations taken from T. D. Wood.*

Present Age	No. Cases	Percent below Standard Weight			Normal Average Zone Per Cent	Percent above Standard Weight			
Yrs.		30–21	20–11	10–6	+5–5	6–10	11–20	21–30	31–40
5– 6	5				3	1	1		
7– 8	8				5		2	1	
9–10	3	1		1		1			
11–12	5		1	1	1	1		1	
13–14	9		2	1	4	1	1		
15–16	11			1	8	1		1	
17–18	7			1	4			2	
19–20	6				2	1	2	1	
21–22	2				2				
23–24	1					1			
25–26	1				1				
27–	1						1		
Total	59								

gain in weight in this series is Case 40, patient a girl, who increased from 53 pounds to 122 pounds in a period of three years and seven months. She is now only 3 per cent above normal standard weight for her height and age.

Table 3 shows the deviation from normal standard weight of fifty-nine of the children in this series. Three cases are not included because of underweight, and tables for calculation are not available (Cases 7, 17, 43). The majority of cases are within the normal average zone, but several show marked deviation from the desired standard. Case 15, patient is 27 per cent below normal standard weight, and has always been below normal weight.

Table 1 records the maximum diet which these children were able to consume during their existence without insulin. By maximum diet is meant the diet which they were able to consume satisfactorily for a period of several months without appreciable hyperglycemia and glycosuria. In some instances the maximum diet is not recorded since the case was admitted with acidosis or coma and insulin treatment was commenced immediately. The diet under insulin treatment is also recorded. It is the diet on which the patient is able to remain entirely or almost a glycosuric for several weeks or months. Table 4 gives the average diets in grams per kilogram body weight and the average total diet for the three groups. The carbohydrate-fat ratio is approximately 1:1 for

TABLE 4—*Summary of the final diets of 62 living diabetic children, with special reference to protein, fat and carbohydrate allowance per kilogram body weight.*

FINAL RESULTS (*Average*)	1 to 5 years	5 to 10 years	10 to 15 years
Weights, pounds	51	83	117
Protein, gm. per kg.	3.0	2.0	1.5
Fat, gm. per kg.	3.9	2.7	2.1
Carbohydrate, gm. per kg.	3.7	2.4	1.6
Calories, per kg.	60	43	33
	P F CH Cal	P F CH Cal	P F CH Cal
Average Diet in Grams	70 91 86 1400	77 100 90 1600	82 121 85 1700

children 1 to 10 years of age and from 10 to 15 years the ratio is 1.6: 2.1. Table 2 summarizes the average duration of diabetes before and after insulin, and the changes in height and weight of the three groups.

A large number of the patients in this series were treated by the author in association with Dr. Frederick M. Allen and thanks is due him for the final summary of these cases.

SUMMARY

The final results of sixty-two living children under insulin treatment is recorded. All are cases which have been under treatment for more than one year. Several of the cases had been treated by diet measures alone for five years or more before the introduction of insulin. The best treatment requires constant sugar freedom and regulation of diet to keep the body weight within normal standard limits. Obese diabetic children are difficult to control. Sugar freedom is best maintained when the carbohydrate-fat ratio is approximately 1:1. Moderate carbohydrate diets permit normal increase in body weight and obviate the difficulties of hypoglycemic reactions and glycosuria. Patients should be instructed to take as much insulin as possible without inducing hypoglycemia, rather than use as little insulin as possible to avoid glycosuria.

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DISCUSSION

FRANCIS SCOTT SMYTH, M. D. (University of California Hospital, San Francisco)—The data presented by Doctor Sherrill is of extreme value insomuch as the number of diabetic children, carefully followed by him, permits conclusions which might be unwarranted from a smaller series. It has seemed to me, however, that not a few juvenile diabetics may lack the typical polyphagia as a symptom and that loss of appetite may indeed be found with polydypsia and polyuria. Doctor Sherrill's figures are also at variance with Joslin's concept that the growth in height of diabetic children is usually below the normal.

Naturally I am enthusiastic over this piece of work since it is in accord with my own ideas. The use of low amounts of carbohydrate to maintain a stability of blood sugar is particularly worth stressing. A high carbohydrate diet may be used on an elderly diabetic, but our experience leads us to believe that it is unsatisfactory for children. From our knowledge of the regenerative power of parenchymatous organs in children as well as from experimental researches, it would seem important to maintain a normal blood sugar even at the risk of occasional hypoglycemia. In fact some have advocated hypoglycemia as the best state for pancreatic regeneration. The education of patient and family is another item of importance. With it should be emphasized the necessity of developing a normal social instinct, lest by pampering the precocious diabetic child he capitalize his infirmity or become hypochondriacal.

One wishes that Doctor Sherrill might later on enlarge his study of these children and give a discussion of the various factors possibly concerned in the etiology of juvenile diabetes.

HOWARD F. WEST, M. D. (1032 West Eighteenth Street, Los Angeles)—Doctor Sherrill's paper covers one of the most important aspects of the treatment of diabetes. There is nothing more interesting than the problem of keeping the diabetic child not alive but normal. This is a new challenge given by insulin. The analysis of the records of this large series of children demonstrates that the attainment of this ideal in the great majority of instances is not impossible, and the results speak for the wisdom of the treatment pursued.

Two points in the paper are especially worthy of special emphasis: 1. Conservatism in diet and insulin prescriptions. Children are sensitive nervously and physically. Their blood sugar, for instance, may swing rapidly from one extreme to the other. Only the most careful management can keep them stable. The ideal diet would seem to be the lowest one that will provide the actual requirements (protein, mineral, vitamin and energy value) for normal development and the lowest insulin dosage consistent with control. Otherwise, as Doctor Sherrill has emphasized, periods of hypoglycemia and glycosuria are almost sure to be present in the same twenty-four hours. It is desirable, from the standpoint of normal metabolism, for the liver to store an adequate amount of glycogen. However, if the diet, and especially the carbohydrate, is in excess and the insulin dosage correspondingly large, excess glycogen will be stored during the periods of insulin activity only to be released as glucose at other periods with consequent hyperglycemia and glycosuria. This occurs typically during the later periods of the night.

2. Training. We frequently say that the success to be obtained with diabetic children depends most largely on the mother. She must be thoroughly trained and must be of the type that can and will exercise constant and wise supervision, not only in regard to the diet and general physical condition, but of almost equal importance that of moral training and discipline. The diabetic child should not be given the privileges of an invalid. He should be held to the same standards of development and behavior as any normal child. As he is apt to be precocious, and as his dietary and physical routines are so closely supervised, there is every reason for his being a truly superior child. The number of diabetic children on the honor rolls of their schools is evidence that this should be expected.